Product Design and Manufacturing

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Lecture - 29d
Software demonstration: Plant Simulation (Part 3 of 3)

Welcome to the course.

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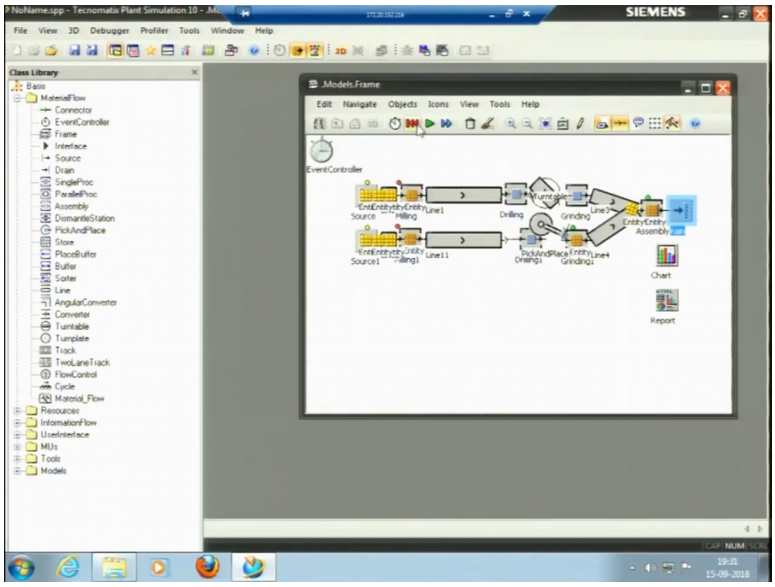

We would be talking about the distributions.

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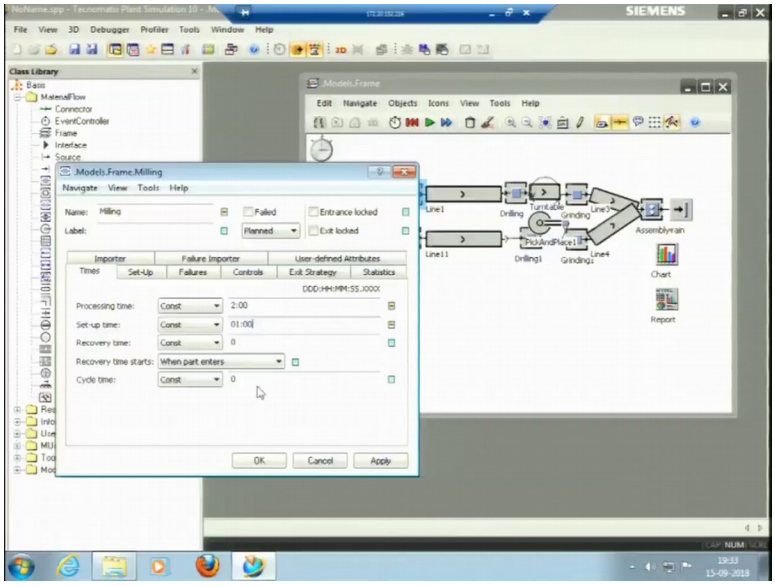

I like to talk about the Distributions, I have just opened this milling process,the processing time for the process is 1 minute. If I took Uniform Distribution, Uniform Distribution is also known as Rectangular Distribution. So, in Uniform Distribution we have a start and a stop, we have the minimum and the maximum value and we also know that the value would lie between these two values and we do not have much information. So, Uniform Distribution and Triangular Distribution and Beta Distribution, these are sometimes known as the lack of information or lack of knowledge Distributions, because we do not have much past knowledge, we just have two or three or five or a very few number of observations. And we do not know what a distribution would it follow, we have just a minimum value and maximum value, we do not know what is happening in between so we just pick this rectangular Distribution.

We know that the Rectangular Distribution just have 'a' value and 'b' value that is all. So, it is showing if we have to put it in this order- stream, start and stop. So I will just put start and stop and the minimum time is taken 2 minutes and the maximum time is 3 minutes . So, here I have just put start and stop and have not put any stream, What is stream?

If we know about random numbers stream is the seed of the random numbers.

when we talk about the simulation; What is simulation?

In Simulation we are trying to imitate the reality and what is representing the reality what is representing our actual real objects or subjects. it is the random numbers, the numbers which you are working on.

So, from where does our random number starts from the specific, so that is stream.

- For an instance if there are two processes, I put the same stream here, same stream means the random number will start from the same seed and the successive random number would be same, for instance if I put the seed value 2 in one process and seed value 2 in another process then the ninth random number that is selected in first process and ninth random number selected in second process, they both would be same because the seed is same so the successive random number would be same. It is recommended to pick a random seed or rather at least a different seed for different processes to have the good simulation process.

If we do not put any stream value here, the software would pick a stream value by itself. I am not picking any entering any stream value, I have just selected Uniform

Distribution. We know that the minimum time would be 2, 2 is too small, let me say the time varies from 2 minutes 50 seconds to 3 minutes, we know that first one is minimum and the second is the maximum.

- First I will talk about Triangular Distribution;

Triangular Distribution is the sum of two Uniform Distributions. Two Uniform Distributions are present there, Uniform Distributions means this just have the smallest value and the largest value and we do not know what would happen.

But in Triangle Distribution we have three values.

1. The smallest value
2. The largest value and,
3. The value that is in between, but repeating for the maximum number of times. It is repeating from maximum number of times that is the value is Mode.

What is mode?. like mean and median, mode is there. mean is the central value median, mean is the average of the values, median is the central location value, mode is the value that has the maximum frequency.

Here we can put, if I pick the triangle Distribution it shows stream c ,a, b here a is the smallest value, b is the largest value and c is the mode, the value that is repeating for maximum number of times. When it is repeating I am talking about the past data in the past data, I have 5 or 6 observations, I know the minimum value and the maximum value, but there is one value which is trying to repeat maximum number of times , I can pick the Triangular Distribution.

Based upon the past data if I have a lot of observations in the past, I can pick normal Distribution, If that fits good here. In normal Distribution, its asking for the parameters, In normal Distribution statistic, it asking for stream, now it is asking for μ and σ. μ is the mean or average and σ is the standard deviation.

Also it is calling for the Lower Bound and Upper Bound; Lower Bound is the minimum value and the Upper Bound is the maximum value within which our Distribution would lie. We should have the knowledge of the Distribution as the softwares are GIGO Garbage In Garbage Out. If you put the right distribution and

you have the right numbers then we are having the results of the simulation very close to the realistic conditions. This is the work of a systems engineer to design it in a proper way.

If I change this time you can see, I do not select apply, because it is showing you know if I do not put it in a proper way this is stream μ, σ, I am showing the value of stream it is just fit. I was showing the value that is 250 and 3 the value of mean was smaller than σ, that is why it is showing the negative value, it would not accept any other format than is required.So, let me pick just constant time here and it was just to make to understand properly it was 1 minute, I will apply this.

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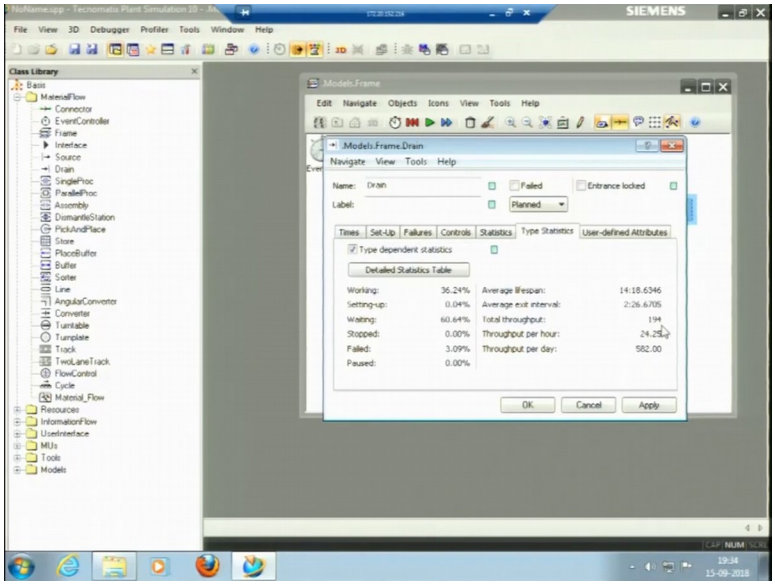

Let me see if I run it for 8 hour a day and try to see the throughput. It is 1167, per hour is 48 and total throughput is 3894 and 8 hours a day.

- ✓ Now, if I change the processing times, let me change this processing time also to 2 minutes, in actual conditions we cannot change the processing time, with the processing that it has to take it would take. The milling ,if it has to take 2 minutes unless we change the tools or we change the machine or we have the CNC machine or have advanced machine we cannot, but work on more on the processing times.

The processing times are fixed in the plant simulation or in the manufacturing simulation, here we can think of working on the bottlenecks. The processing times are fixed, we can think of designing the layout in a way that material flow is minimum

and that the total time taken is minimum total time taken would be minimum that means, the total throughput would be the larger.

- ✓ if I change this time and now I increase the time to 2 minutes and then I run the process and let me try to see the throughput here you can see the throughput was larger before. It has reduced now because the processing time is increased it is 582 pieces per day and 194 pieces in 8 hours a day.

Also we can have the setup time as well, for instance if a workpiece is to be manufactured it will take 2 minutes for processing and 1 minute for setup,1 minute for setup means for instance some milling is happening, In milling process what do we do we just rotate the tool and remove the material. It is removing the material for one workpiece this is a 2 minute process and after 2 minutes the machine stops, this workpiece is taken off and a new workpiece is brought in here that is the raw one and it will start process on this raw one workpiece now this setup takes 1 minutes here. So, this is setup time, this is processing time. If I induce setup time as well and apply.

Let us see what happens to my throughput now only in 1 line, I have put some setup time. So, the throughput is further reduced, here it was 197 pieces so it is 194 pieces now because the setup time is there now another 1 minute is being taken. So, total time taken in the milling process in the line 1 is 3 minutes now , this was a brief introduction about the software the major or the main objects that we can use.

I have some examples for you to show you different layout and also the experiment manager we will use. We will try to see the simulation that we can do in the software. So, this is continuous material flow, I will select two lane track here so traffic circle or segment table traffic circle, pick and open the model.

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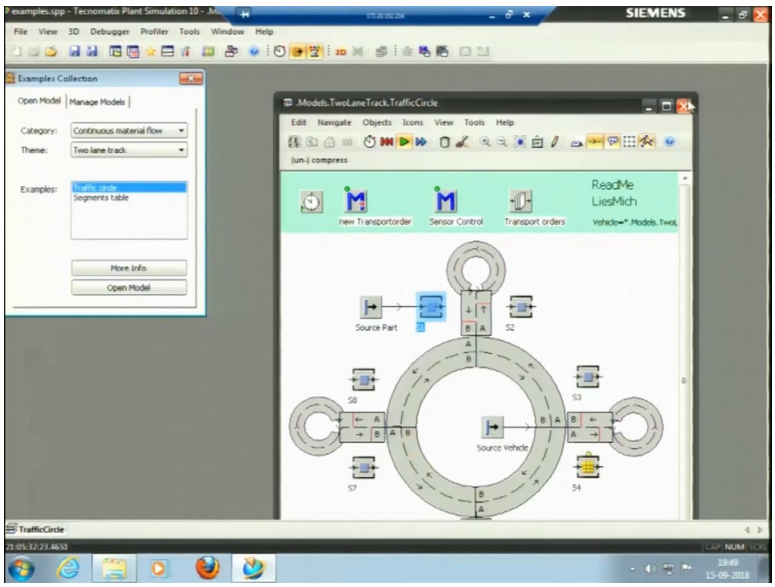

- So, this is the model it is already running, I will just run the model you can see this is the trolley that can pick material

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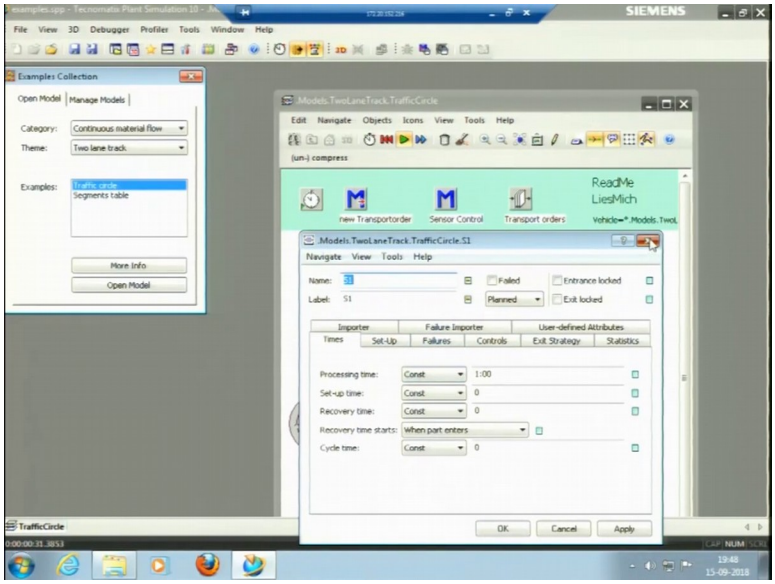

thus this is source part some processing is being done here, I can see what is the time of the processing here the time is constant that is 1 minute. You can see it is happening, I will make it little faster, control panel and then run, this trolley is running, trolley is continuously running through the tracks, this is actually about 20 times faster. The processing is happening it is happen for the 9 minutes but it is not stopping, what is the setting because there is no end time thus it will continue for the infinite amount of time, this is a kind of a just a cell, an 'o' cell, now cancel and stop.

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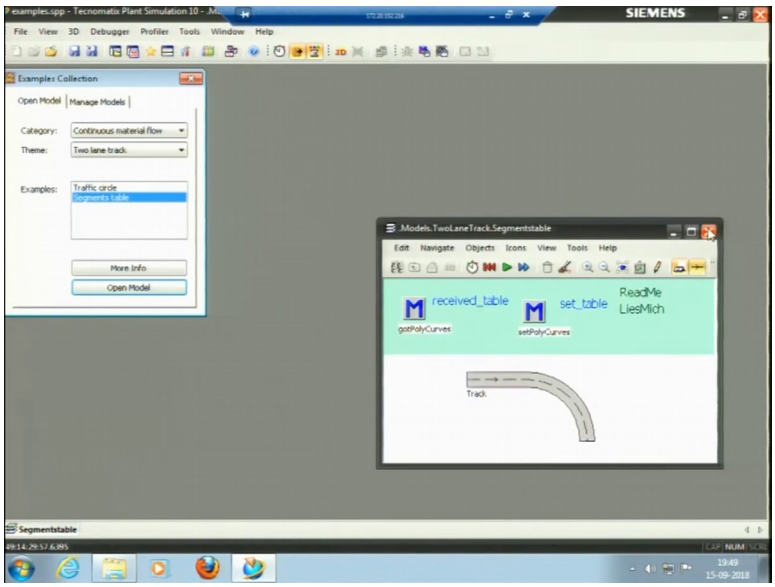

The segment table open model, this is just showing a track, all the track is built

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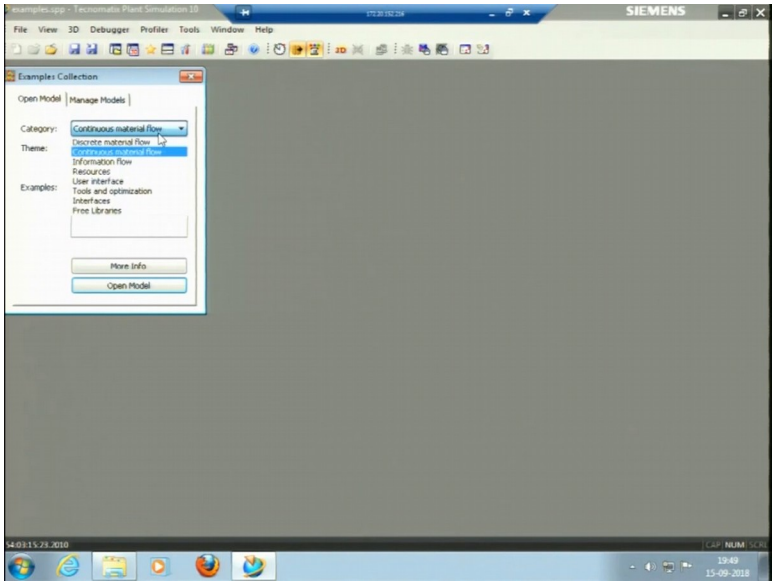

So, let me pick user interface dynamic statistics display panel or chart open.

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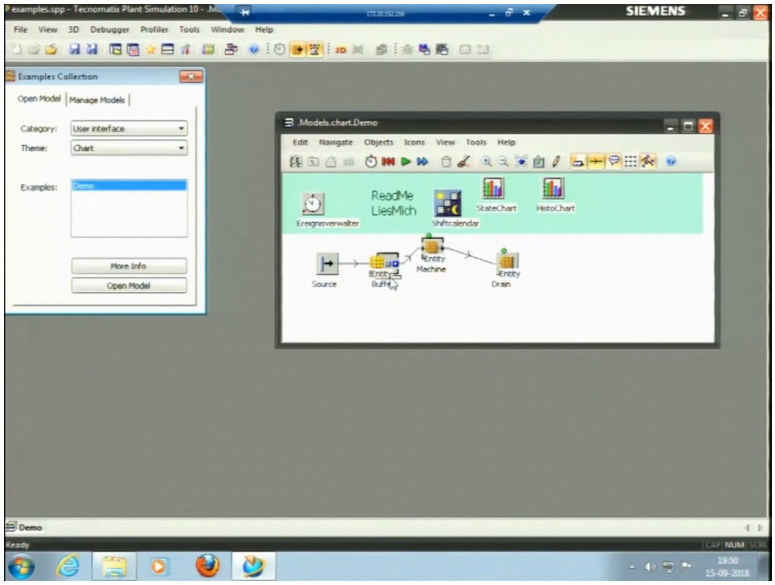

In this model we can see the chart what is setting there is that it has no end time, I will put the end time here 0 8 :0 0: 0 0 apply ok, it will try to run this model, so it has a run for 1 day. Entity buffer is there, entity machine is there.

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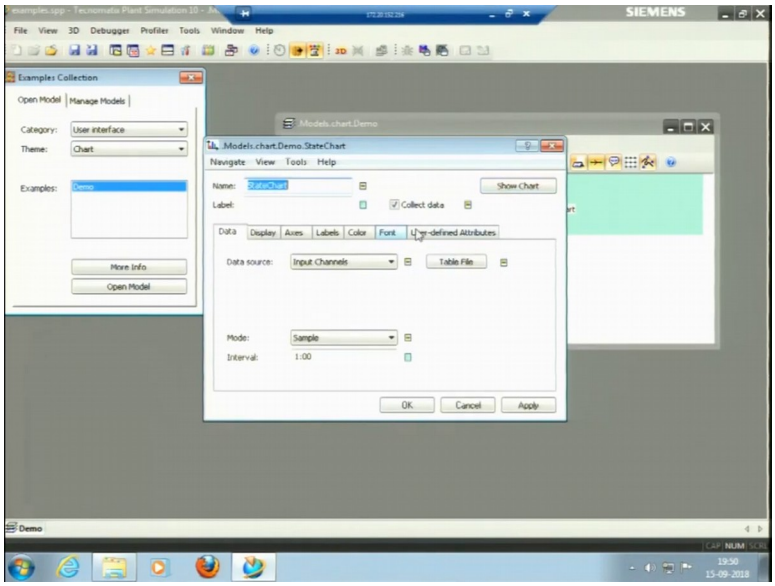

So, we can see the charts here.

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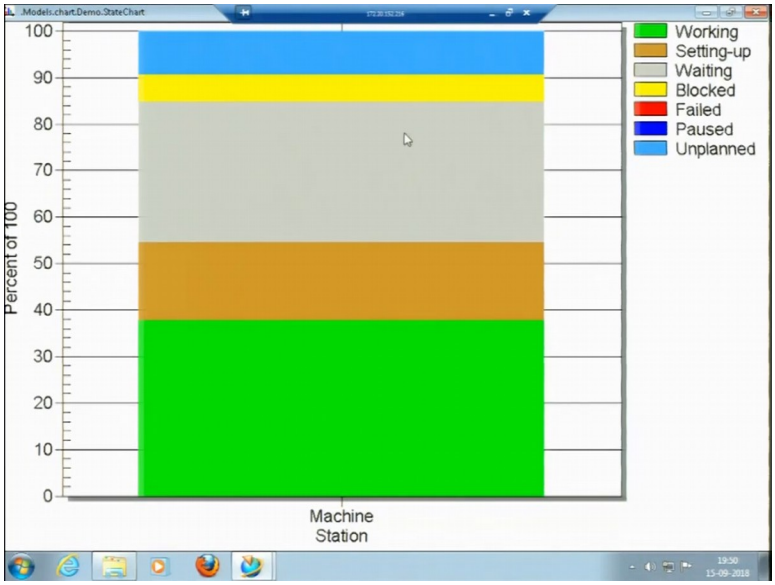

So, for only one machine it is showing the chart that this is something unplanned blue colour is unplanned then we have blocked(yellow), then we do not have any failure here we

have this waiting time for the about 30-37 percent of time it has been working. So, this is another example, then tools and optimization, the important part is Experiment Manager, I will just pick the buffer line optimization, this is line comparison open model.

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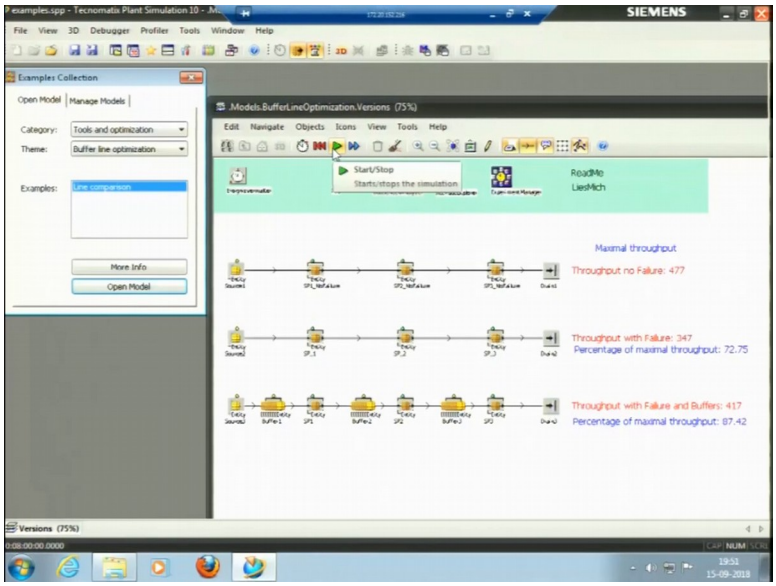

In this model we have three lines and it is given here that this now. In this line the throughput with no failure, this is throughput with failure, throughput with failure and buffers. So, there is a buffer kept in between, if I enlarge it, this is buffer ok this is another buffer. So, I have kept buffers in between this is throughput we need to see the throughput with no failure, in another line is throughput we have put some failure rates here.

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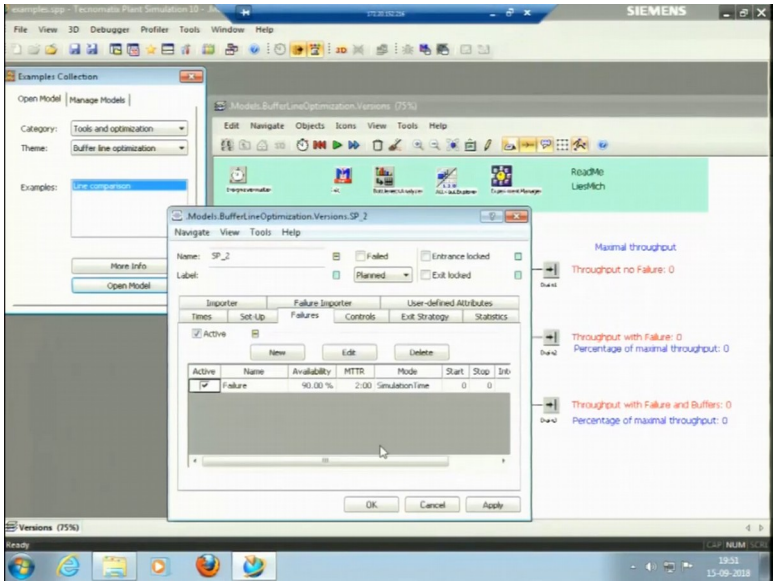

If I see the failure it has 90 percent failure, 90 percent availability, it is 10 percent failure. In this case there is no failure in the first case there is no failure.

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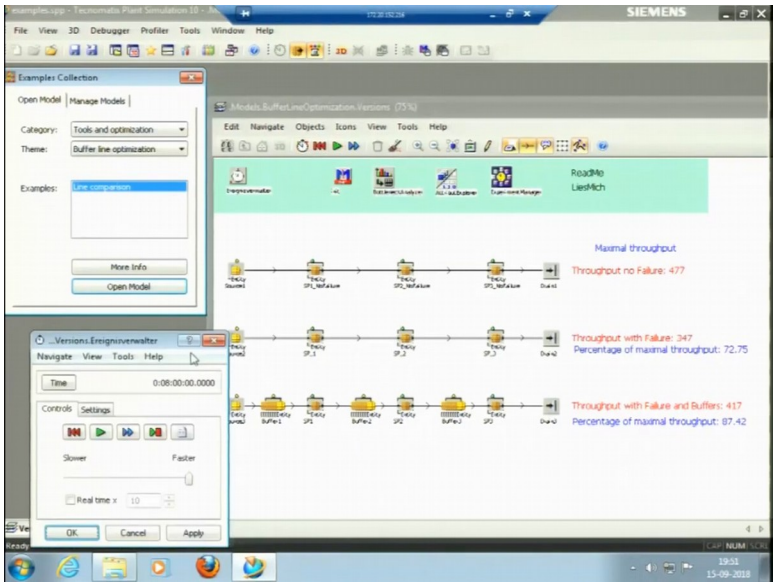

Let me try to run this model yes this model has run for 8 hours a day. For no failure the pieces in a day work for 477 with failure it is 347, but because failure is there we have put the buffers in between that can store some of the material so it is about 417, also it is giving the percentage of the maximum throughput, the maximum throughput is 477,it is with failure we have 72 percent but with buffers it is 7 percent of the throughput of the maximum value.

Then I can pick some interface o k I can pick the File Interface, open model then in the source, I can see Broker and animation. So, shift calendar worker, I will show you a worker introduction model.

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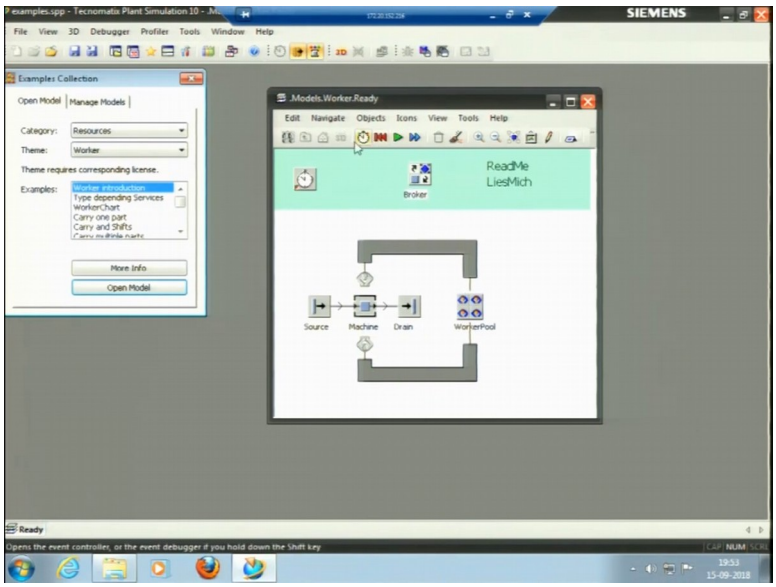

This is the worker introduction model, in this case you can see the workers are just introduced into machine and if we run this. Let me try to make its little slower, apply now run,

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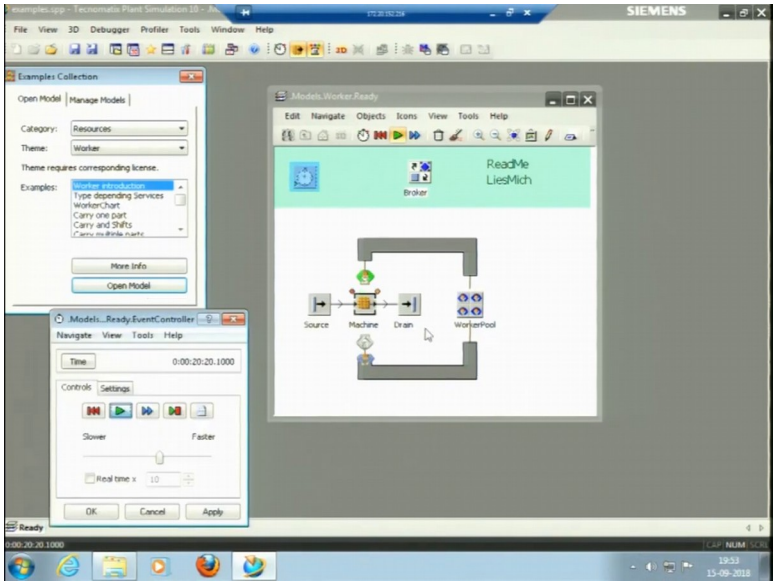

you can see the workers were running, two workers, one worker is working here and second worker is here.

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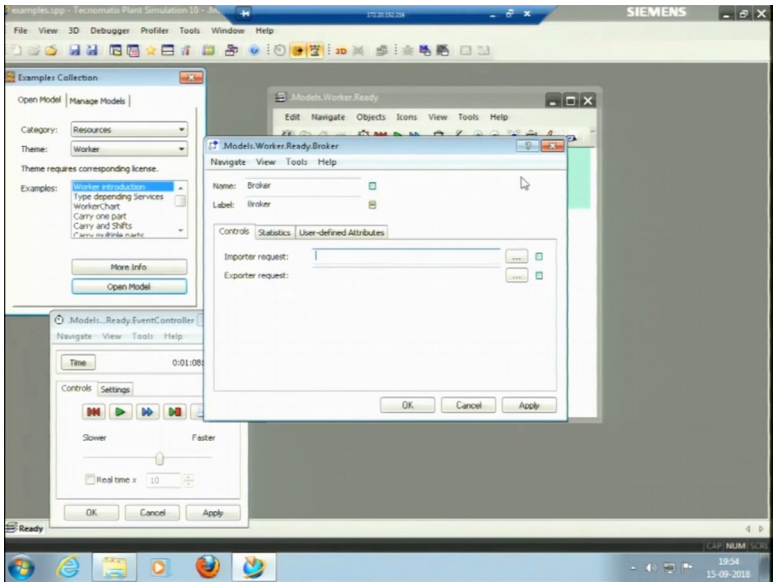

I can see the number of workers here in the work pool, in work pool, controls, entrance plant.

I can see the number of workers are two here and work pool is there and the broker is there, broker is trying to distribute the work to different workers. This is one of the example then let me come to the major simulation thing, that is the experiment manager, tool and optimization experiment manager.

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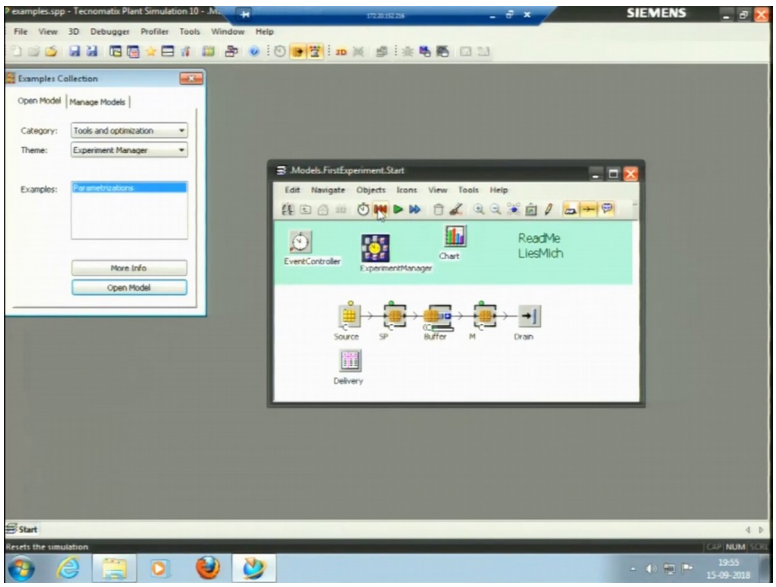

This is one of the models we have experiment manager this experiment manager can show the simulation

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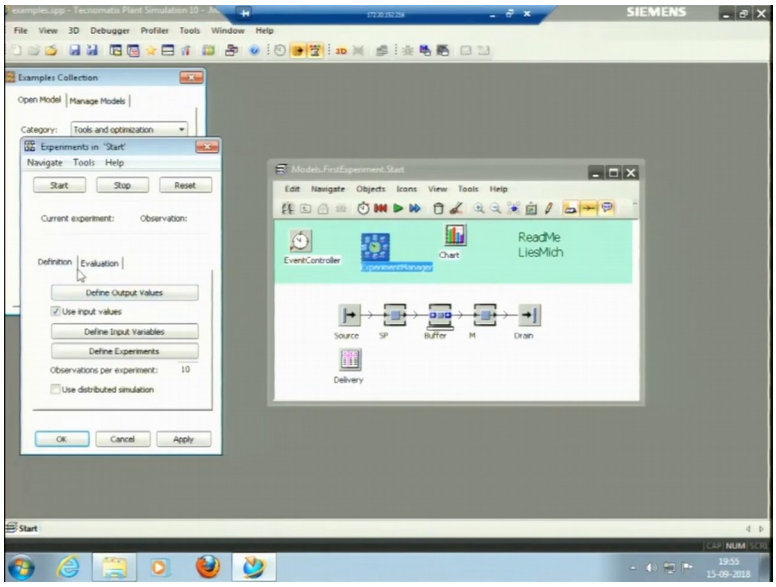

If I run this model for let me open this experiment manager for instance definition and evaluation

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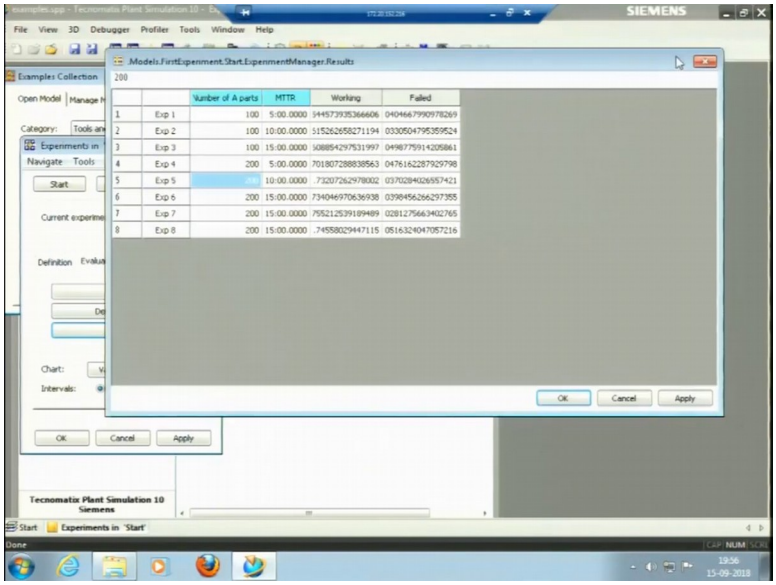

In definition we have defined the output value output value of the workstation portion, start fail portion, it is working and failed. So, what output do we need and what inputs do we have input is the root delivery and mean time to repair.

If I run this model also I can define the experiments that is for number of 100

number of parts mean time to repair is this much 5, 10, 15 then 5, 10, 15 this is for 100 parts, this is for 200 parts again. So, these number of experiments would run if I run this experiment manager ,let me try to run, it has run for 8 hours Now, seeing the results.

It has shown the results at mean time to failure if it is kept 5, so it is working for this much number of time, it is failed for this much number of time. For this simulation of a 100 ,this is for 200 parts, so it has taken eight experiments so I can see the report as well here

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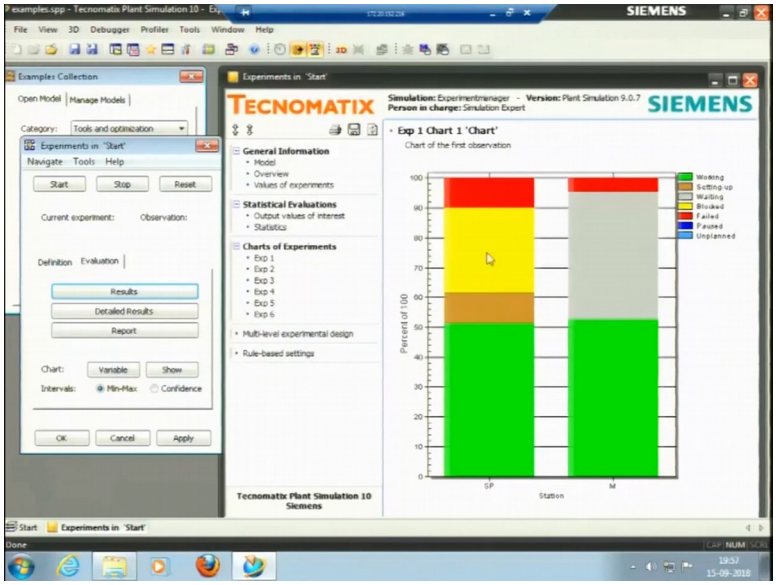

In the report it is telling that there are number of experiment in experiment one, this happened in experiment two, this happened this is the total failure this is both blocked time then grey colour is waiting time, all these things it is telling in the report.

In experiments what is it taken? It has taken different random numbers in experiment number one, different numbers are random numbers are taken, experiment number two different numbers are taken. What is experiment number one it was given here output values are here in this result, experiment number one is 100 parts with mean time to repair as 5 minutes. Experiment number two is 100 parts with mean time to repair as 10 minutes.

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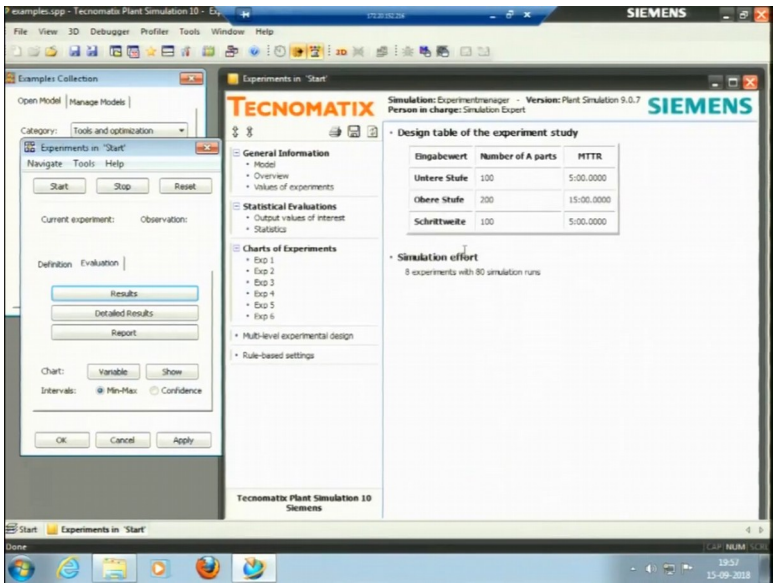

So, it is showing these experiments here. We can have all different kinds of designs.

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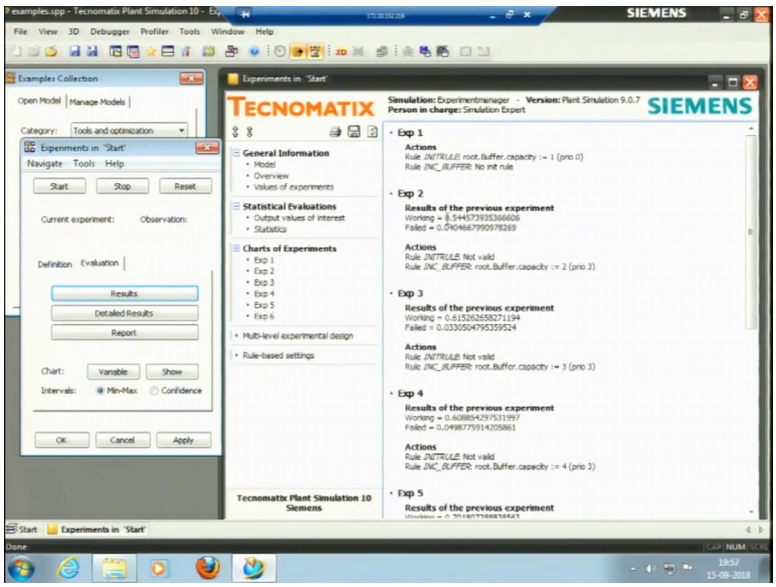

then rule we have not defined any rule based setting can also be done. This is like if we go to the detail of the simulation these things are possible.

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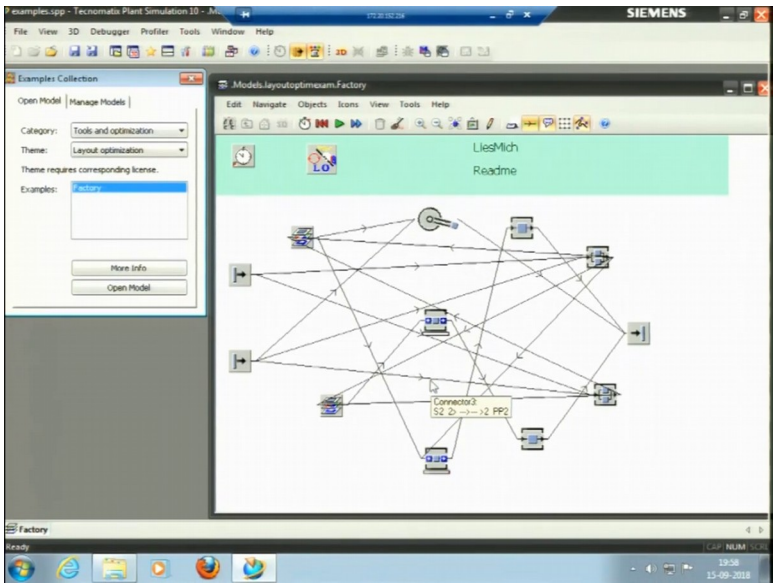

Now layout optimization, factory optimization factory layout is there this is a factory and we have made different kind of connections here. Layout optimization can be done where to keep what machine then what would be the overall, what would there maximum throughput if we do that. So, this can these models can be also we can through these things to find the optimization here.

Another model I can pick here is from continues material flow, two lane track distance control, sensors; sensors are like if we need to for instance if we need to accelerate at some point or we need to put breaks or we need to put the correct decision light and like we open this model.

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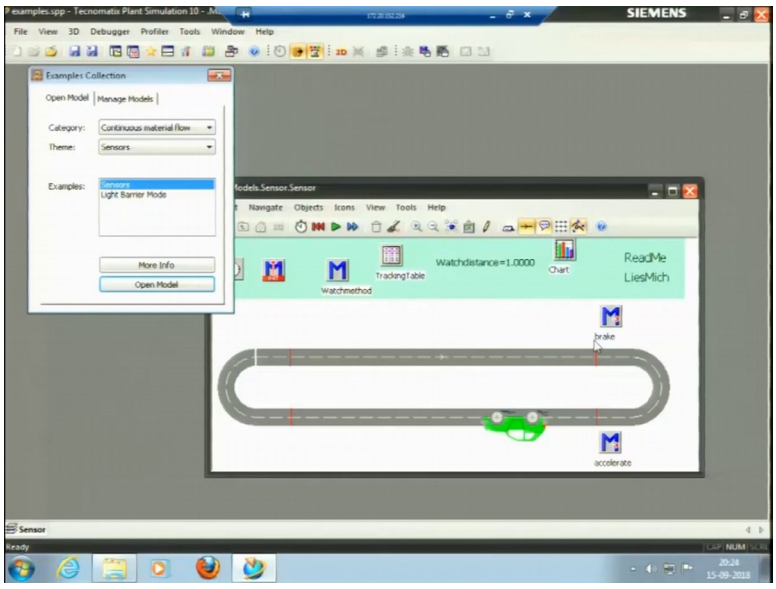

This is an break and accelerate model. I have defined the method, if I try to run this model.

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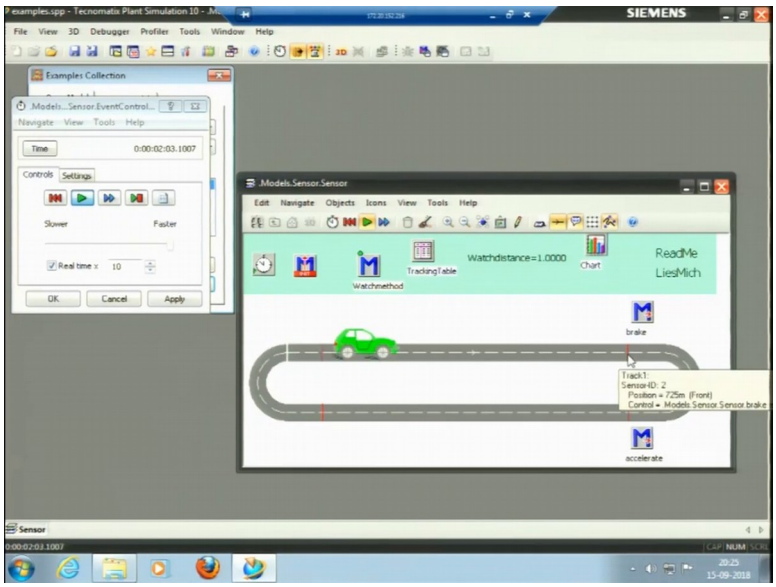

first let me see the event simulator but just to see whether how it runs you can see this is break after break it will just slowdown after accelerate, it accelerate this is speed in this speed. At this point break would apply, it will accelerate now the break would apply, it will take a turn accelerate, it will accelerate from this point.

This is a kind of a entity, this car here we had just one kind of a entity

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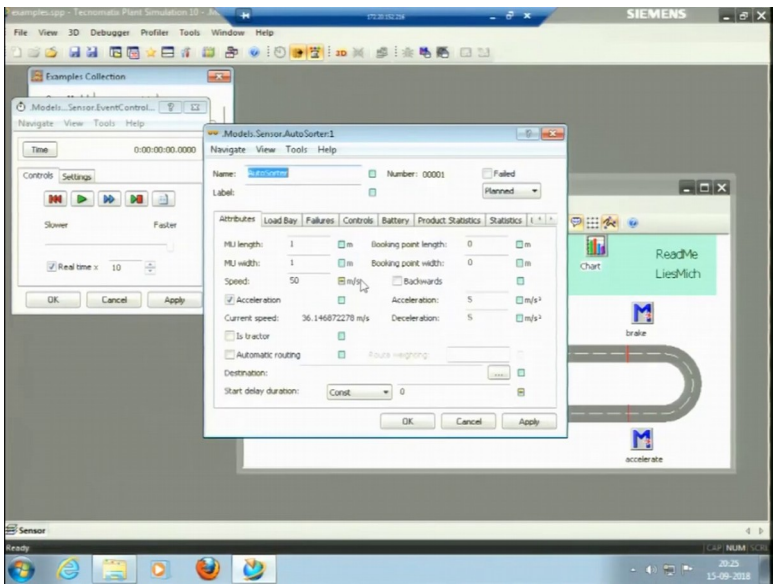

There is another entity which is in the form of car, the name is auto sorter. This was by sensor in continuous material flow they have many models in this. I will just

pick randomly something some tools and optimization. I can pick experiment manager, then I will try to explain a experiment manager in more detail, Let me pick something with transfer station. I have a demonstration model here.

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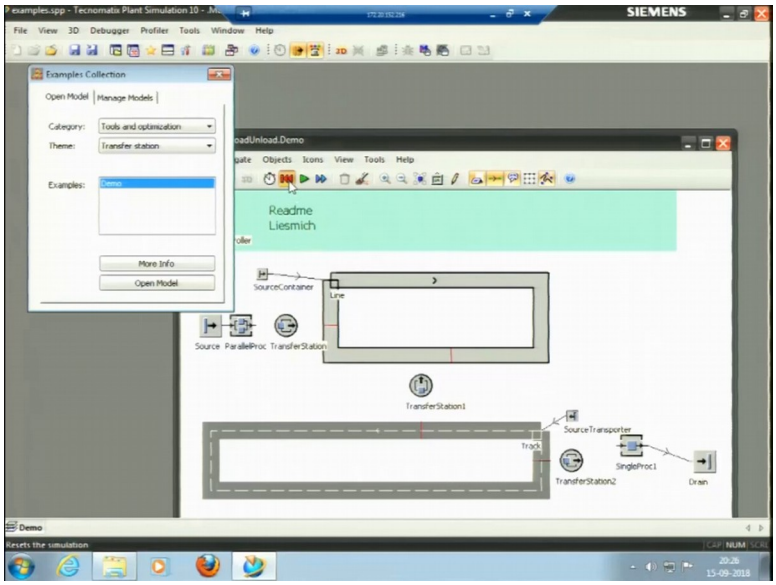

Transfer station is one cell , this ‘o’ is 1 cell, this is another track here two way track . Transfer station, it will just transfer the material from this cell to this track let me try to see the event simulator, here you can see the trolley or the container came here. The container is coming, some machining is happening at this Parallel Process .

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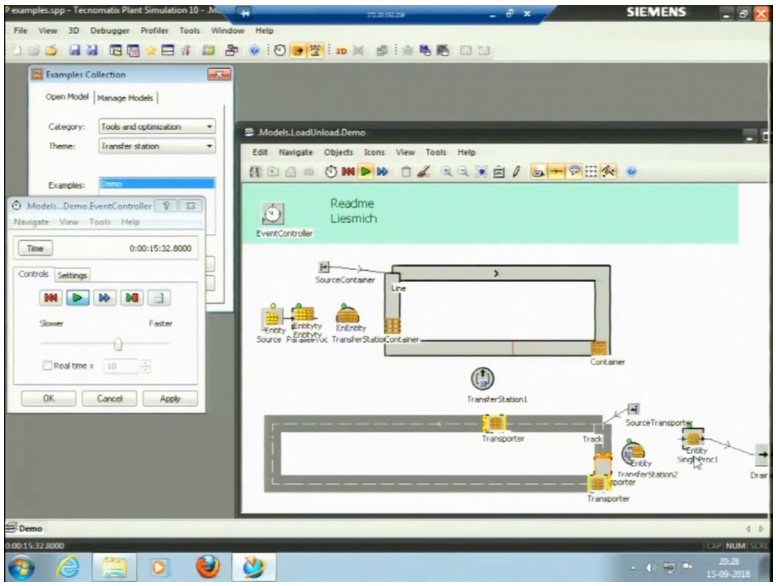

Let us first see what are the process parameters here

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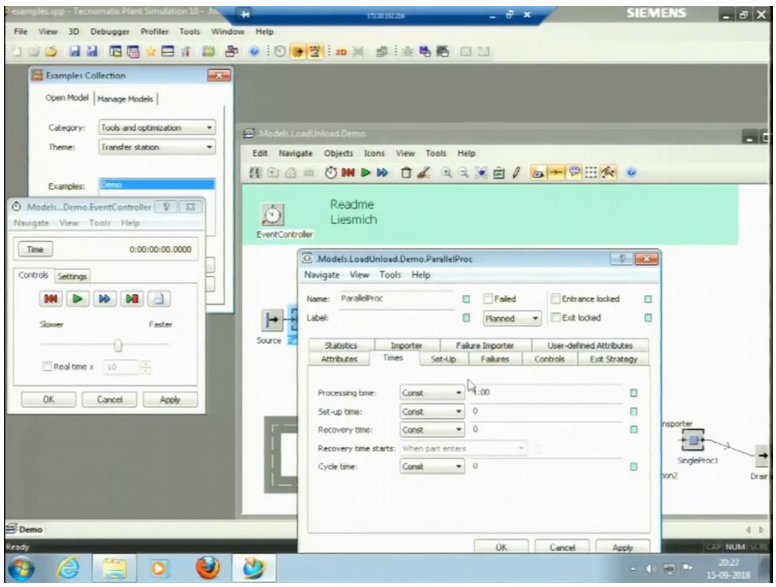

this is a Parallel Process in which 2*2=4 processes are there and the times is again the default time that is 1 minute . from this source it comes in transfer station, there we need not connect transfer station, when we see a transfer station.

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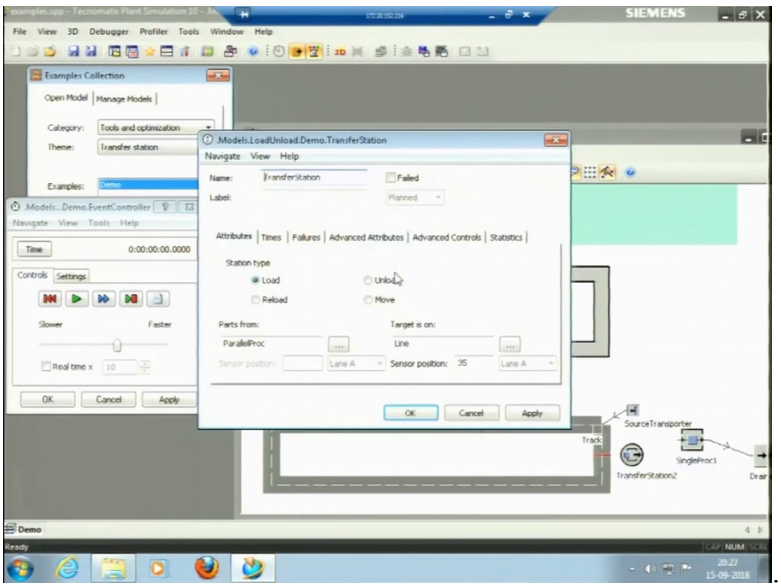

It will transfer into load, it will just load the process it is connected, connect path from the parallel process we just need to put the name.

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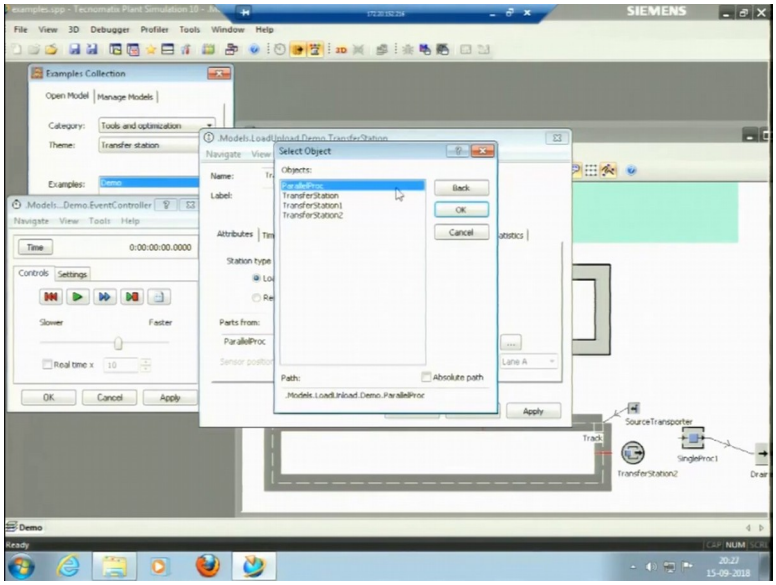

It will pick the part from parallel process then it will target or the transport the parts to line, there is no connector required in between we need to just mention the predecessor and the successor process. sensor position is this one, all these so we can select load, unload, reload, move so it is loading the parts. All these attributes availability is 100 percent we can select this, I would not change anything and let me try to run the simulation. So, these containers are running, some processing is happening here. It will take 1 minute, so transfer station will transfer the part to this container. So, this container is coming here and at this transfer station it is connecting the part from this line 1,2,3 to a track, if I see its properties it forms a line to a track, the name of this track is track only.

here is another transfer station, a source transporter as well in which source is there that is trying to transport material from some other frame or some other user interfaces, it is trying to do that. This is one of the objects that can be used, so this is say transfer station. After applying there are certain examples which are available for us to see how these things happen.

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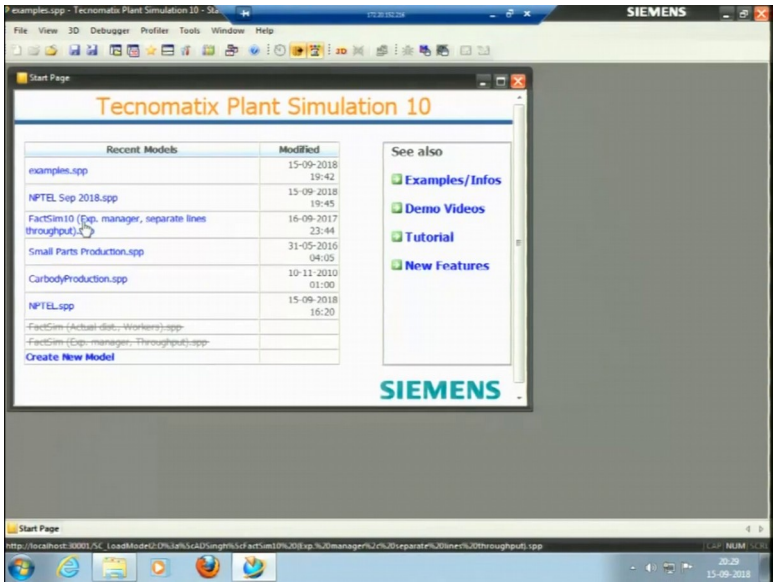

I will just open start page again and try to open this factory simulation that we had made earlier.

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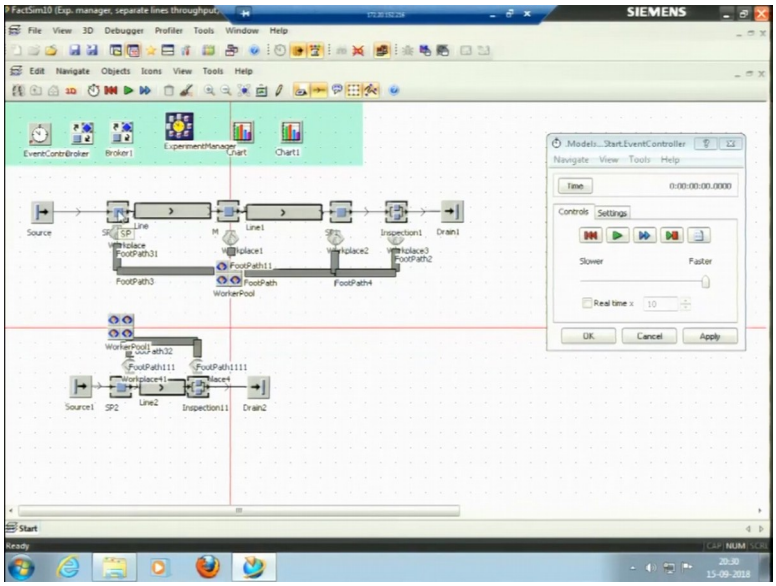

So, this is a factory simulation in which these processes are there this is the process if I put the names this is the single process one and single process two, single process

three and the workers are working, here the time for the workers are put. The speed of the worker which is defined by International Labour Organisation is 80 meters per second and the times for different machines are taken in such a way that if it is an automated Machine.

The time is actually noted while doing live experiments, so live experiments were conducted. This is single process, here it is milling. I have not changed the name. So, this is milling, its time is kept constant here and this time is 1 minute and 10 seconds like that is about 70 second it takes to do the machining then setup time is about 26 seconds. So, for this machine, these are actual times which are taken from the experiments as live experiments were conducted.

So, these are the time for second machine, about 2 minutes that is 1 minute 55 seconds, 59 seconds for the processing and for setup it takes 33 seconds, these are all taken constant here.

This run for 8 hour a day and also in an experiment manager we have defined the output values, output values are the one which are working and failed and throughput of line 1 and throughput of line 2 we need to see, like we can just see throughput here in the previous way we did. We can just see the throughput of this run that we have done, it is 534 pieces per day and 178 pieces in 8 hour a day but if I run my simulation using my experiment manager.

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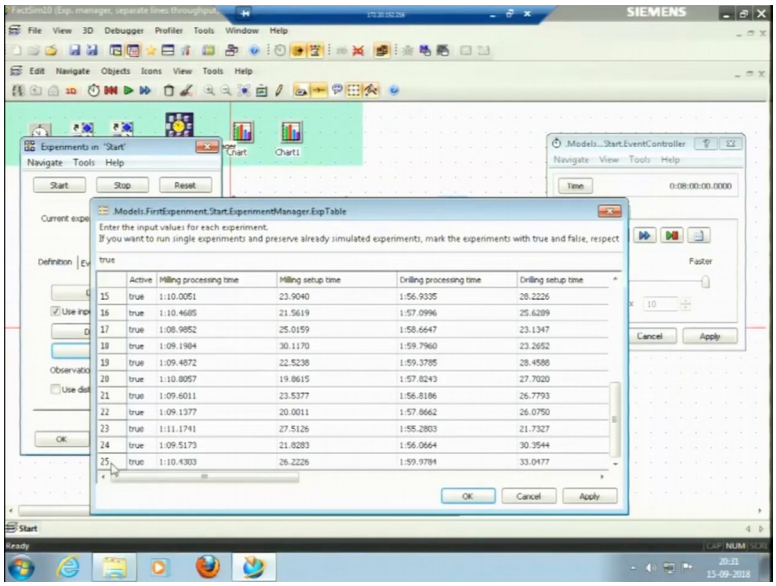

I have defined 25 experiments here, and the processing time is taken actually 59 seconds

and this 70 seconds is calculated using random number table or using some random Distribution, Normal Random Distribution may be. So, we have selected a random times those random times are put here 70 seconds was the mean and this is the real random times. It has 69, 70,71 so these are the random times, setup times are also random.

These times are putting times for milling processing and setup, drilling processing and drilling setup, grinding processing and setup then after grinding, we have inspection. We have these machines here, milling machine, drilling, grinding, inspection one.This is throughput to line 1.Then workers their places, worker footpath all those things are defined in the model we made. This is an hypothesized factory.

So, defining observations per experiments, so there are 25 experiments which are conducted using random numbers and per experiments 50 application would be taken that is 50 times one experiment would repeat. The box plot can be made for this 50 experiments, that is one observation, one observation means 50 experiment, the second observation is another 50 experiments. So, Total number of experiments that happen is 25 into 50.

- Total number of experiments=25
- Number of applications per experiments=50
- Box plot for 50 experiments=1 observation
- Total number of experiments=25*50

  =1250

So, 25 experiments are made and 50 observations per experiment. Input variables are all the times of processes such as milling, drilling, grinding, processing and setup times, inspection one and in the second line we have a Modern Manufacturing Machine which is Micro wire EDM (Electric Discharge Machining). So, This is a modern manufacturing machine ,so in this case all setup time is put, so these three machines inspection two is there so the 2 lines with which you can see are the two flow lines.

First flow line is the conventional machines milling, drilling, grinding and Second flow line is our modern manufacturing, source micro wire EDM then inspection and drain. So, we can see the both throughputs used after connecting these experiments.

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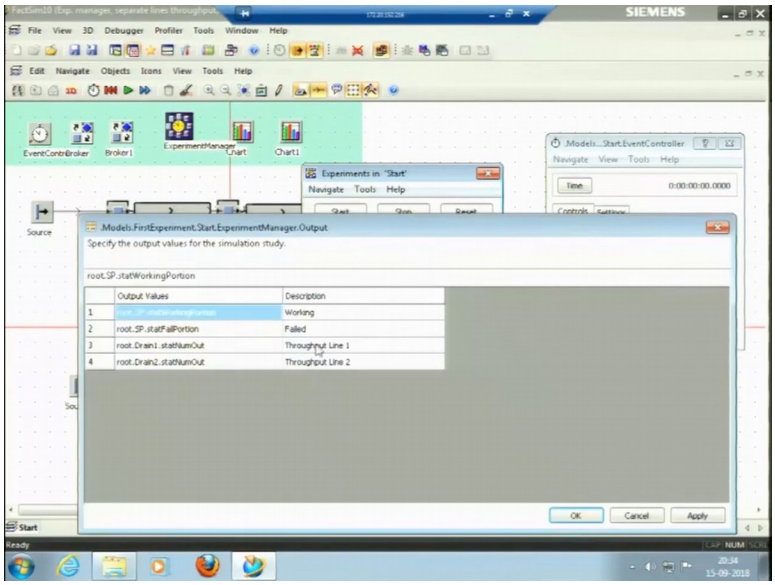

So, output values are all defined we need to see throughput 1, throughput 2 and also we need to see the working and the failed percentages.

Let us start the simulation, current experiment is one if you see, third experiment is running fourth is running now, fifth is running. Fourth, fifth, sixth experiment. 50 observation for all the 25 experiments 50 observation would run. So, you can see the time 8 hours, 8 hours, 8 hours, it is running the multiple runs here, this is how the simulation is conducted using the experiment manager.

This is the exactly the simulation is used for ,you know actually 6000 experiments are

conducted.

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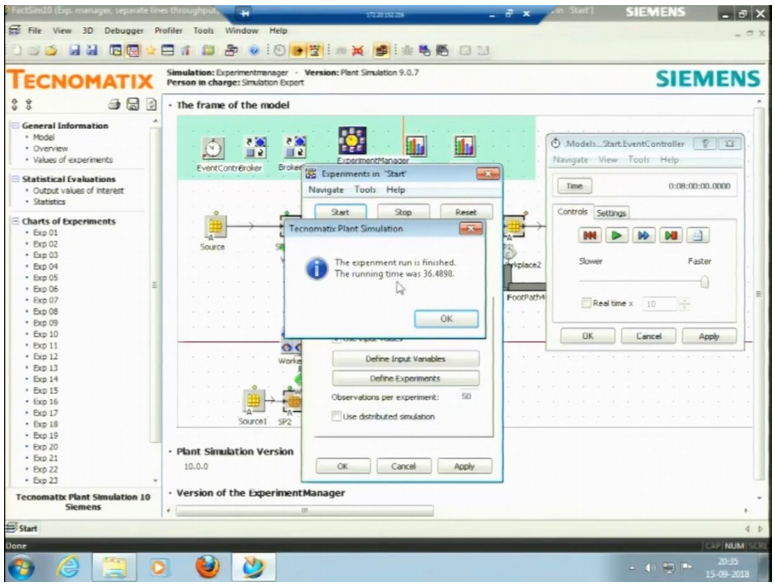

So, it has generated a report total running time for the simulation is 36 seconds. In 36 seconds it has run 1250 experiment, 1250 is 25 into 50.

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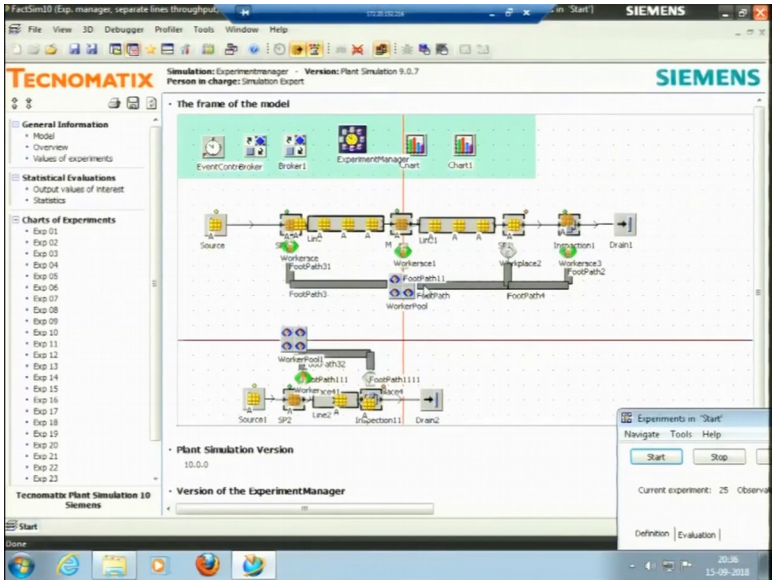

so this is my report saying ok this is the simulation, this is the final which that we are getting here this is simulation experiment , whenever if we like to see.

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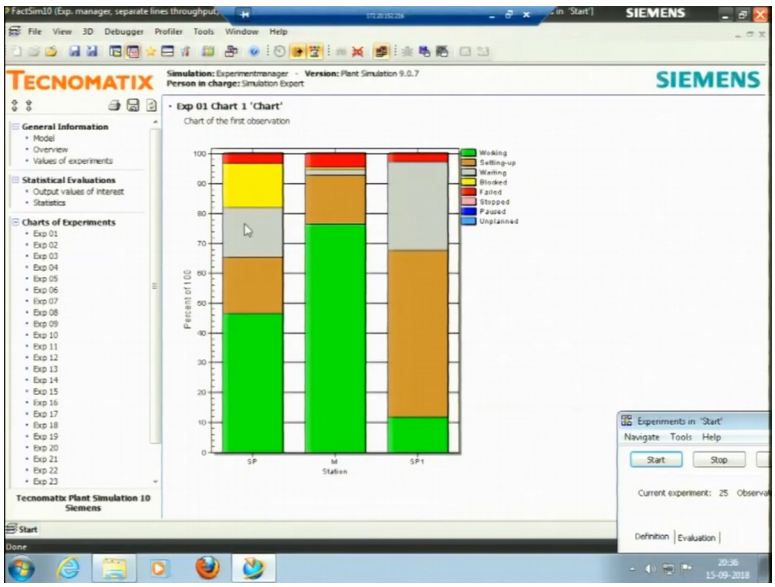

It has shown that single process one-station one and single process one, it is showing that these are the time for which it is working, this is the time for it is blocked, this is showing these things experiment number two also showing same things.

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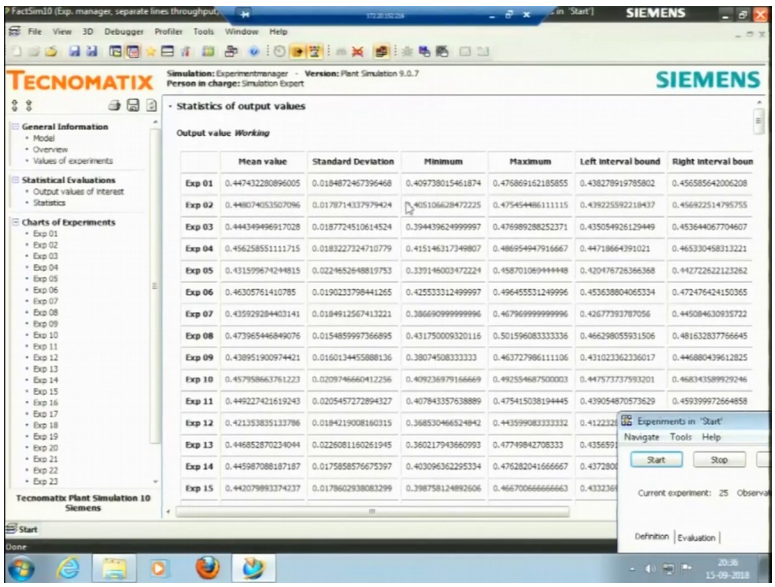

So, it is showing the statistics here so mean value, standard deviation, minimum and maximum for experiment one and for all the experiments

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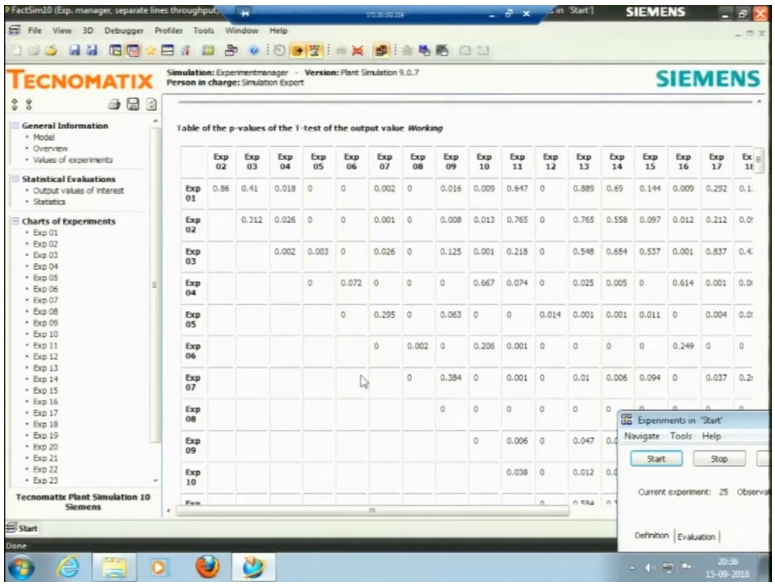

So, this is the P and T test we will do not move to that these are the tests those are conducted and this is table for that

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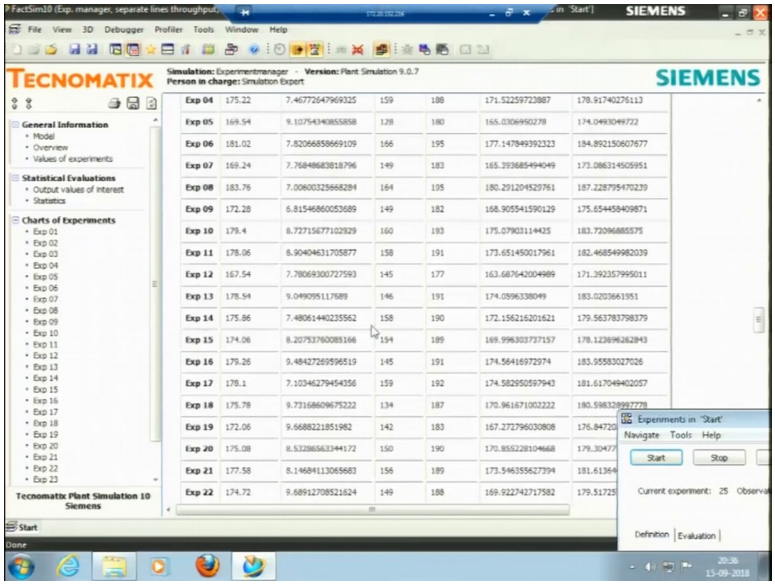

It shows time such as failed time, working time and also it will show the throughput because we asked for a throughput. So, this is the throughput for the 25 experiments so this is the throughput for the 50 observations in experiment number one. Experiment number one means 50 observations that 25 experiments for each experiment there are 50 observations.

So, experiment number one has 50 observations, these 50 observations have this mean

177.4, these 50 observations have this standard deviation, it has this minimum value and this maximum value, left and right bound is also given.

So, for all these 25 experiment it is taken the overall mean also throughput of line 1, throughput of line 2.

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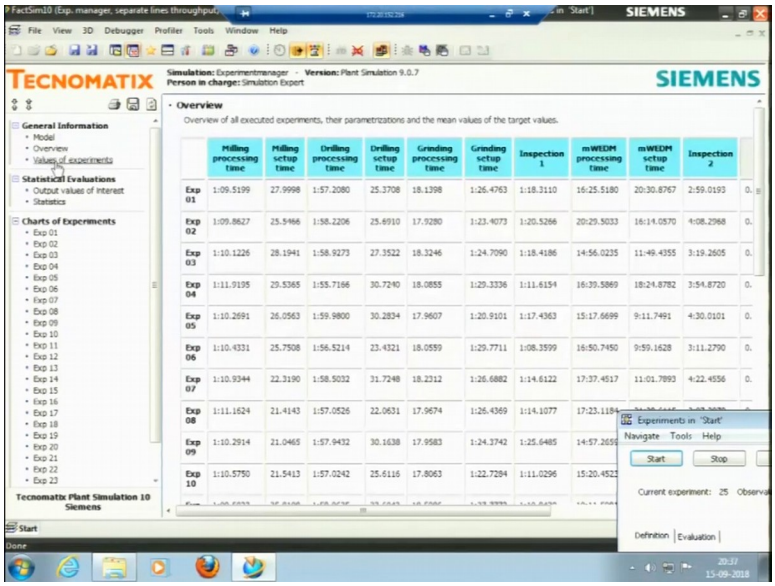

Let's see the values of Experiments.

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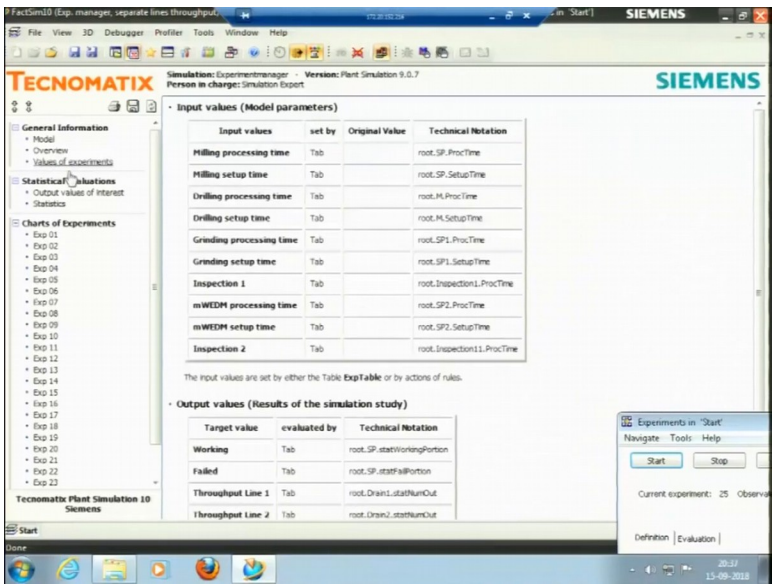

Let me try to see the plots of these.

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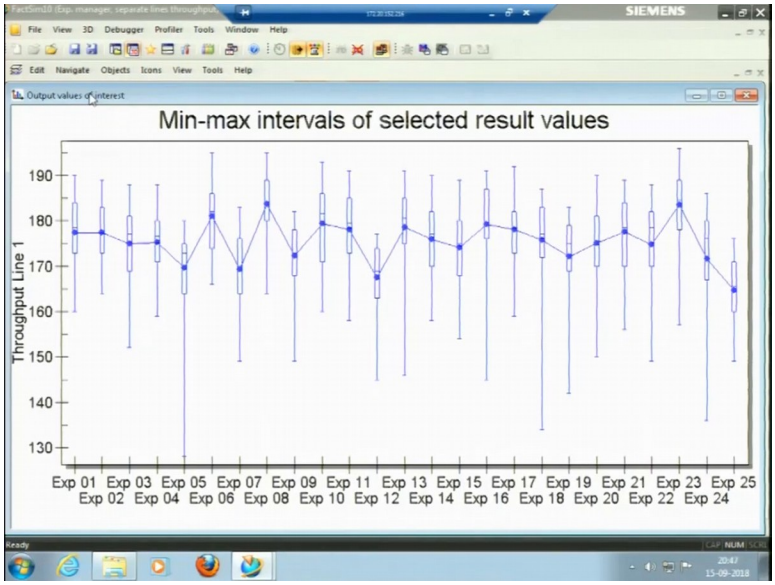

So, these are the output values of interest.

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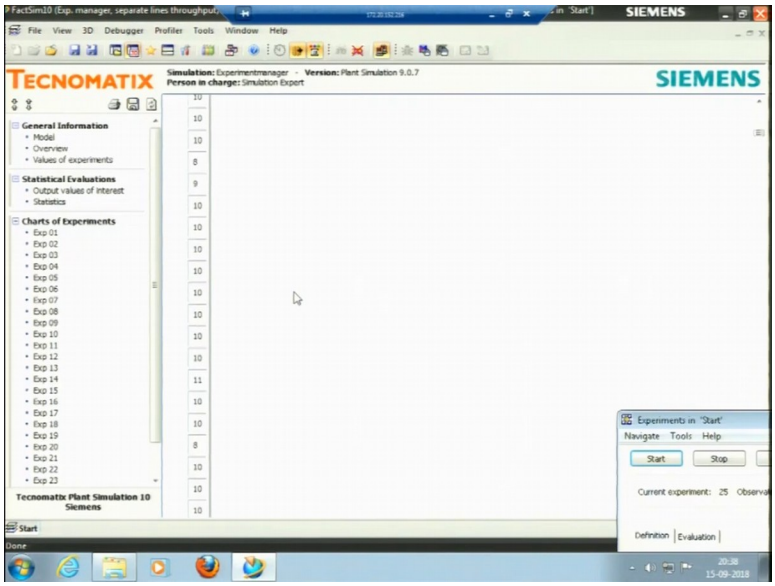

So, if you see these, this is each experiment and 50 observations are given, this is for the throughput 2 you can see now we have a box plot here. So, now, what does this show? This for instance, this is my experiment number 5, this vertical line in experiment number 5 shows that there are 50 observations.

And this is box plot this is my median and you can see there is whisker and the third quartile is quite lower and we do not have the first quartile, first quartile is kind

of coinciding with my quartile two. So, the upper whisker is very smaller, so it is from the box plot for each of the experiments. We can see the very small variation here in experiment number 11, in experiment number 16 you cansee again there is a big variation on the lower side. You can also see the overall variability is very high, It is there because it is the behavior of the micro EDM.

Number one, In Micro EDM process we do not know the kind of experiment which we did,we did not know that what time it would take, some time it took may be 50 ,sometime it took 10 minutes, 15 minutes, 20 minutes, variability was there in the overall process that is why this big variability is there.

Number two is that the throughput is very small actually the final throughput is obtained, the average throughput was 14 pieces hence throughput is very small. So, with this small throughput it is showing very high variation like in a day we can see that we even have about 9 pieces in a day, here we have about 15 pieces in a day . So, the total throughput is very small so that is why this is much high variability is there.

So, for throughput line 1, so this I have obtained the chart put for the throughput of line 2. So, here you can say in the throughput for line 2 the variability is less, the two reasons for this are, number one the processing times were in control because the machines were CNC machines when we connected the live of experiments. However, the processing time for the inspection was little variable because inspection was done manually but overall because of they were three automated machines. So, the variability is lesser than that we observe in our line 2.

Second reason is the overall average is 178 which is a big number and like bigger number then that very small number 14. So, the throughput variability is lesser however, in individual processes because the simulation is trying to re imitate the realistic situation. So, in realistic situation we can have the outlier, we can sometime have the very long time or a very lesser time then it should be normal.

So, this for instance in experiment number 5 you can see again the whisker is falling down, it all depends upon the random numbers and if I tell you the time were kept constant, but the seeds were all different. So, depending upon different seeds for these different experiments and the observations were also very different these different box plots are obtained .

So, we can infer that the variability is lesser in this and we can keep varying the number of workers.

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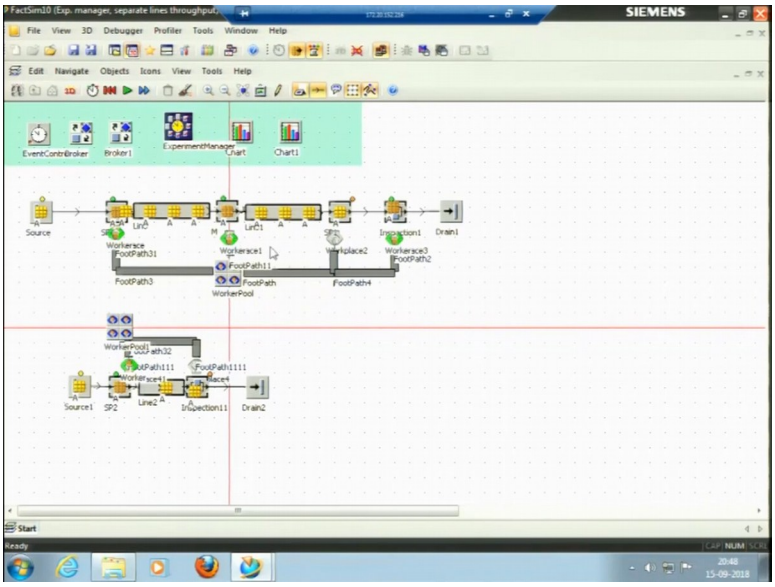

The number of workers those who are employed were 4 you know 1, 2, 3 workers in line 1, 1 worker in line 2 , we can also think of employing 5 workers that is 4 worker in line 1.

If we employ another worker we can do cost analysis, what is the wage of that worker and what is the overall throughput, what is the increase in the throughput. If the increase in the throughput is lesser than the profit that we obtained from the increased throughput by employing the fourth worker is lesser than the wage that has to be paid to the worker. So, we can just take of the decision we can just deny this decision.

So, the certain experiment that we can do certain simulation that we can do I think, I should stop here, we have discussed enough about the Tecnomatix software for an amateur, this is a good start like you have an introduction to how the software work. And how is simulation is conducted in the software, then what are this types of layout and we can even optimise the layout using these softwares. And just certain you know I have told you this is a great capability of this specific software, but yes we can keep on using this, we can try to simulate the factory we

can make a big factory and this is just a manufacturing process in manufacturing systems.

We can also think of taking after this manufacturing system, this is developed. The systems or the actually report that we have got we can take that report, the team centre to finally, support when actually things happen. So, we can just put, this is the schedule or the plan, what is the variation of the actual things which are happening in a first few runs; when we actually run this kind of setup. So, we can test those as well using these software tools, so I will have to stop here and thank you for being in the course so we will meet next time.

Thankyou

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